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PRISM SHEET HAVING CONCAVE PENTAGONAL

Background of Invention

Technical Field

The present invention relates to a prism sheet, and more particularly to a prism sheet in which each individual prism constituting a prism sheet has a concave pentagonal structure, thereby improving luminance and expanding the viewing angle thereof.

Background Art

A Liquid crystal display (hereinafter, referred to as a "LCD") is one of image display devices, and has quickly replaced other display devices such as a cathode ray tube (CRT) due to various advantages, for example, its thin thickness and low electric power consumption, as compared with other display devices. In contrasted with the CRT, the LCD does not spontaneously emit a light ray and thus needs a back light unit, in addition to a liquid crystal window.

Conventional backlight units are categorized generally into an underneath type, an edge type and a taper type. The underneath type comprises at least two lamps arranged in parallel at the lower part of a light guiding plate (will be hereafter described), and the edge type has two lamps, but which are provided at both sides of the light guiding plate respectively. In the taper type, a single lamp is provided at one side of the light guiding plate, the lower part of which is slanted. Accordingly, the energy consumption increases in the order of the taper type, the edge type and the underneath type.

FIG. 1 is a perspective exploded view of a conventional taper-type backlight

unit. FIG. 2 illustrates a perspective view of the construction of a conventional prism sheet. As shown in FIGS. 1 and 2, a reflective plate 4, a light guiding plate 2, a diffusion plate 5, a lower prism sheet 6, an upper prism sheet 7, and a protection plate 8 are stacked in sequence above a mold frame 9. Although not illustrated, a liquid crystal panel is placed above and spaced apart from the protection plate 8. A lamp 1 is disposed at one side of the light guiding plate 2 and enclosed with a lamp reflector 3.

On the other hand, as shown in FIG. 2, the conventional backlight unit comprises the upper prism sheet 7 and the lower prism sheet 6, which are stacked one above the other. The lower prism sheet 6 consists of a plurality of elongated projections 6a, which are arranged in parallel. Each of elongated projection runs in the same direction and has a transversal cross-section of isosceles triangle, thereby forming a prism. Similarly, the upper prism sheet 7 has a plurality of elongated projections 7a thereon, which have the same configuration as the lower projections 6a, with exception that the upper and lower projections 6a, 7a are arranged perpendicularly to each other.

In the conventional backlight unit having the above-described construction, a light ray emitted from the lamp 1 passes the light guiding plate 2 directly or after reflected on the reflector 3, and then, via the diffusion plate 5 and the prism sheets 6 and 7, enters the liquid crystal panel, where resultantly a desired image is formed. At this time, the light ray emitted from the lamp 1 enters the light guiding plate without leaking outside by means of the reflector 5, and is uniformly scattered therein. The scattered light ray is made more uniform while passing the diffusion plate 5. The light ray emitting from the diffusion plate 5 is refracted at a specific angle when pass the prism sheets 6 and 7, and finally enters the liquid crystal panel.

In particular, the light ray is uniformly aligned at the orientation of 90 or 180 degrees and amplified while passing the orthogonal projections 6a, 7a of the prism sheets 6, 7. The conventional backlight unit described above is exemplified by Koran Patent Publication No. 58166 (published on July 5, 2001), and other type of backlight unit is disclosed in Korean Patent Publication No. 55377 (published on July 4, 2003).

However, the conventional prism sheet is structured such that each individual prism has a cross-section of isosceles triangle, in which only two oblique sides (legs of the isosceles triangle) can make contribution to the increase in luminance, thereby resulting in a limited efficiency of increasing the luminance.

Disclosure of Invention

Therefore, the present invention has been made in order to solve the above problems in the prior art, and it is an object of the present invention to provide a prism sheet having a concave pentagonal structure, in which each prism has a shape of concave pentagon to provide additional faces which can make contribution to increase in luminance, thereby providing an improved luminance and a widened viewing angle.

To accomplish the above object, according to one aspect of the invention, there is provided a prism sheet having a concave pentagonal structure. The prism sheet comprises a base layer; and a prism array disposed on and supported by the base layer, the prism array consisting of a plurality of prisms aligned in parallel and one beside the other, wherein the transversal cross-section of each prism has a shape of concave pentagon, which is symmetrical about a vertical line passing the apex, and wherein the interior angle α of the apex is $30° \leq \alpha \leq 120°$, the exterior angle β

formed by the upper slant side and the lower slant side is $\beta < 180°$, the interior angle γ of the lower vertex formed by the lower slant side and the base is $5° \leq \gamma \leq 85°$, and the length w of the base is $30\mu m \leq w \leq 100\mu m$.

Preferably, the interior angle α of the apex may be $40° \leq \alpha \leq 100°$, the exterior angle β formed by the upper slant side and the lower slant side may be $160° \leq \beta \leq 179°$, and the interior angle γ of the lower vertex formed by the lower slant side and the base may be $30° \leq \gamma \leq 60°$. Preferably, the length w of the base may be $40\mu m \leq w \leq 60\mu m$.

Brief Description of Drawings

Further objects and advantages of the invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective exploded view of a conventional taper-type backlight unit;

FIG. 2 illustrates a perspective view of the construction of a conventional prism sheet;

FIG. 3 schematically illustrates a prism sheet having a concave pentagonal structure according to one embodiment of the invention;

FIG. 4 depicts a detailed structure of one prism in the prism sheet of FIG. 3;

FIG. 5 shows a simulation of light scattering path in the prism sheet according to the invention;

FIGS. 6a to 21a show a prism structure according to the invention, where the

interior angle of the apex is incremented by one degree from 71° to 86°, and a relative distribution of luminance with respect to each viewing angle;

FIG. 22a is a graph collectively showing horizontal luminance distributions with respect to each viewing angle in the graphs of FIGS. 6b to 21b; and

FIG. 22b is a graph collectively showing vertical luminance distributions with respect to each viewing angle in the graphs of FIGS. 6b to 21b.

Best Mode for Carrying Out the Invention

Referring to the accompanying drawings, the preferred embodiments according to the present invention are hereafter described in detail. Before illustrating details of the preferred embodiments of the invention, a brief explanation of the light refraction at an interface boundary of two materials having different indices of refraction will be provided below.

In general, when a light ray passes an interface boundary at an arbitrary angle, it is bent, i.e., a change in its travelling path occurs. This is called the refraction of light. The refraction principle is applied to a prism, which is used in a microscope, a binocular, a backlight unit or the like. The refraction of light takes place according to the Snell's law, which is expressed by the following equation where a light ray passes an interface boundary of material 1 and material 2 having a index of refraction n_1 and n_2 respectively and the incidence angle and refraction angle are θ_1 and θ_2 respectively.

$$n_1 \mathrm{Sin}\theta_1 = n_2 \mathrm{Sin}\theta_2$$

FIG. 3 schematically illustrates a prism sheet having a concave pentagonal structure according to one embodiment of the invention, where the prism sheet is generally denoted at a reference numeral 20. FIG. 4 depicts a detailed structure of

one prism in the prism sheet of FIG. 3. As shown in FIGS. 3 and 4, the prism sheet 20 of the invention comprises a base layer 22 and a prism array 24 placed thereon. The prism array 24 consists of a plurality of prisms, which are aligned one beside another and in parallel. The prism array 24 is supported by the base layer 22.

As illustrated in FIG. 4, the transversal cross-section of each prism is formed of a concave pentagonal configuration, which is generally denoted by a reference numeral 24. The concave pentagonal structure of the invention can be explained with reference to an isosceles triangle cross section of conventional prism. That is, each leg of isosceles triangle is bent inward in such a manner that the inward bending forms an additional vertex, which is a bending point lb, rb dividing the leg into a upper leg 24_{us} and a lower leg 24_{us}(also, referred to as a "upper and lower slant side), thereby configuring a concave pentagon. In this pentagonal structure of prism, the sum of interior angles is 540°, regardless of a degree of inward bending. It is preferred that the pentagonal structure of the invention is symmetrical about a vertical line passing the apex a of the pentagon.

According to the invention, in the concave pentagonal cross-section of the prism, the interior angle α of the apex a is $30° \leq \alpha \leq 120°$, preferably $40° \leq \alpha \leq 100°$. An exterior angle formed by the upper slant side 24_{us} and the lower slant side 24_{us}, i.e., the exterior angle β of the bending point lb and rb is $\beta < 180°$, preferably $160° \leq \beta \leq 179°$. The interior angle γ of the lower vertex lc, rc formed by the lower slant side 24_{ls} and the base 24w is $5° \leq \gamma \leq 85°$, preferably $30° \leq \gamma \leq 60°$. The length w of the base 24w is $15\mu m \leq w \leq 100\mu m$, preferably $40\mu m \leq w \leq 60\mu m$.

FIG. 5 shows a simulation of light scattering path in the prism sheet

according to the invention. As illustrated in FIG. 5, the prism sheet of the invention has a total of four refraction faces so that a wide viewing angle can be realized, along with an improved luminance. That is, the upper leg (slant face) renders an incident light to be bent or refracted in a vertical direction, thereby making contribution to improvement in the luminance, and the lower leg (slant face) makes the incident light be spread in a horizontal direction, thereby providing for a widened viewing angle.

FIGS. 6a to 21a show a prism structure according to the invention, where the length of the base, the height of the prism and the interior angle γ of the lower vertex are fixed to 50μm, 26μm, and 45° respectively, and the interior angle α of the apex a is incremented by one degree from 71° to 86°.

FIGS. 6a to 21a also illustrate a relative distribution of luminance with respect to each viewing angle in the above-described prism structure. In the experiments of FIGS. 6a to 21a, SPEOS (trademark, supplied by OPTIS, France) is used. Furthermore, each resultant distribution graph of FIGS. 6a to 21b shows a relative luminance distribution scanned in a horizontal and vertical direction, where two prism sheets of the invention are employed, placing them vertically to each other. The luminance is a relative value to a reference value 1, where only a single sheet of light guiding plate made of polymethyl methacrylate (PMMA) is used.

FIG. 22a is a graph collectively showing horizontal luminance distributions in terms of relative values, with respect to each viewing angle in the graphs of FIGS. 6b to 21b. FIG. 22b is a graph collectively showing vertical luminance distributions with respect to each viewing angle in the graphs of FIGS. 6b to 21b. The maximum luminance values and the maximum relative values in the graphs of FIGS. 6b to 21b are summarized in the following table 1.

<Table 1>

	Maximum Luminance Value	Maximum Relative Value
Light Guide Panel Only	0.333233	1
Conventional Triangle Prism	0.513272	1.58
The invention ($\alpha = 71°$)	0.787870	2.37
The invention ($\alpha = 72°$)	0.774849	2.33
The invention ($\alpha = 73°$)	0.774612	2.34
The invention ($\alpha = 74°$)	0.812868	2.44
The invention ($\alpha = 75°$)	0.806116	2.42
The invention ($\alpha = 76°$)	0.753511	2.26
The invention ($\alpha = 77°$)	0.791157	2.38
The invention ($\alpha = 78°$)	0.759934	2.28
The invention ($\alpha = 79°$)	0.778343	2.33
The invention ($\alpha = 80°$)	0.765696	2.30
The invention ($\alpha = 81°$)	0.769455	2.31
The invention ($\alpha = 82°$)	0.784998	2.36
The invention ($\alpha = 83°$)	0.780085	2.34
The invention ($\alpha = 84°$)	0.821674	2.47
The invention ($\alpha = 85°$)	0.776861	2.33
The invention ($\alpha = 86°$)	0.812238	2.44

As understood from the above table 1, the relative luminance value of the prism sheet having a concave pentagonal structure of the present invention is considerably increased more than 2.2 to 2.5 times, as compared with the case where only a light guiding plate is employed. Furthermore, the relative luminance value is increased, as compared with a conventional prism sheet, for example, having an isosceles triangle structure.

The following table 2 shows a luminance value of a backlight unit for the use in a LCD display device of cellular phones, in cases where two prim sheets of the present invention are employed with installed perpendicularly to each other, and a

conventional isosceles triangle prism sheet is used.

Table 2

	Minimum Value	Maximum Value	Average Value
Conventional Triangle Prism	5400.139844	15121.79844	8041.159734
The invention ($\alpha = 60°$)	8750.1377	23051.0567	11822.256
The invention ($\alpha = 65°$)	8712.994	22704.757	11855.658
The invention ($\alpha = 70°$)	8569.271	22710.97	11945.199
The invention ($\alpha = 75°$)	8712.264	22960.995	11848.111
The invention ($\alpha = 80°$)	8643.641	22905.015	11837.592
The invention ($\alpha = 85°$)	8632.468	22491.008	11765.966
The invention ($\alpha = 86°$)	8754.375	22331.111	11763.244
The invention ($\alpha = 87°$)	8439.195	22245.92	11718.57948

It is understood from the above table 2 that, as compared with a conventional prism sheet having a isosceles triangle structure, the prism sheet having a concave pentagonal structure of the present invention shows an improved luminance with respect to all the minimum, maximum and average values in the range of 60° to 87° of the interior angle α of the apex a.

Industrial Applicability

As described above, the prism sheet having a concave pentagonal structure according to the invention provides for an improved luminance and a widened viewing angle. Therefore, when the present invention is applied to a backlight unit for a display device of various mobile communication terminals, TV and the like, the fatigue of user's eye can be considerably alleviated, and the deterioration of luminous efficiency due to the use of a polarizing file can be minimized, thereby providing an extended life of the backlight unit. In addition, the underneath-type backlight used in the LCD television can possibly be replaced by an edge type by

applying the present invention thereto, therefore reducing the manufacturing cost of LCD television.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by the embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention. For example, the present invention may be applied to a self-luminous organic electroluminiscence display in order to improve the luminance of backlight. Also, the prism sheet of the invention can be employed as a light guiding plate. Furthermore, the present invention can be applied to a self-reflecting film used in a light reflector of a road guide rail, a road central line, and a vehicle, or the like.